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ROLL STAND COMPRISING A CROWN-VARIABLE-CONTROL (CVC)ROLL PAIR
[WALZGERÜST MIT EINEM CVC-WALZENPAAR]

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TITLE	(54):	ROLL STAND COMPRISING A CROWN-VARIABLE-CONTROL (CVC) ROLL PAIR
FOREIGN TITLE	[54A]:	WALZGERÜST MIT EINEM CVC-WALZENPAAR

The invention pertains to a roll stand with a pair of CVC rolls, preferably with a pair of CVC working rolls and a pair of backup rolls, which have a contact area in which a horizontally acting torque is present, which leads to a skewing of the rolls and thus to axial forces in the roll bearings.

EP 0 049 798 B1 describes a rolling mill with working rolls which are supported either by backup rolls or by backup rolls and intermediate rolls, where the working rolls and/or the backup rolls and/or the intermediate rolls can be displaced axially with respect to each other and where each roll of at least one of these roll pairs is provided with a curved contour which extends toward one of the ends of the barrel, which contour extends toward each of the two opposite ends of each of the two rolls across a portion of the width of the rolled stock. In this case the cross section of the rolled strip is affected almost exclusively by the axial displacement of the rolls provided with the curved contour, so that there is no need to bend the rolls. The curved contours of the two rolls extend over the entire length of the barrel and have shapes which, in a certain axial position of the two rolls, fit together in a complementary manner.

EP 0 294 544 B1 discloses rolls with contours which are described by a fifth-degree polynomial. This roll shape allows even more complete corrections of the rolled strip.

In the two documents cited above, however, no attention is paid to the fact that not only the roll gap and the profile adjusting range play a role when CVC rolls are used for rolling. The amount of attention which must be paid to the roll bearings is also affected by the axial forces acting on the rolls, especially those which can arise when an unsuitable grind is used.

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Because of the difference, although small, between the diameters along the length of the barrel of a CVC roll, different contact forces and peripheral velocities are produced.

The circumferential velocities are equal at the points on the paired rolls which have the same diameter. At the other points on the contact area of the rolls, the diameter and thus the circumferential velocity of one roll is smaller or larger than those of the other roll. Thus, depending on the how the directions of the coordinates are defined, a negative or positive velocity differences is produced along the contact area between the paired rolls.

These different relative velocities and their different directions lead to different circumferential forces, which act in different directions. The distribution of the circumferential forces on the rolls results in a torque acting around the center of the stand, which can lead to a skewing of the rolls and thus to axial forces in the roll bearings.

The invention is based on the task of providing measures for a roll stand of the generic type, by means of which the axial forces acting on the roll bearings are minimized. The task is accomplished by the characterizing features of claim 1. Simply by modifying the shape of the CVC rolls, the torques acting in the horizontal direction are minimized without additional effort.

A suitable modification of the shape is achieved according to the invention by defining the change in the radius of the CVC roll by the polynomial equation:

$R(x) = a_0 + a_1 \cdot x + a_2 . x^2 + \ldots a_n \cdot x^n$

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and by using preferably the so-called wedge factor a_1 as an optimization parameter. The contour of a CVC roll is defined by a third-degree polynomial:

$R(x) = a_0 + a_1 x + a_2 x^2 + a_3 x^3$

where:

L = the radius of the CVC roll;

a_i = the polynomial coefficient;

and x = the coordinate in the longitudinal direction of the barrel.

In the case of CVC rolls of higher degrees, additional polynomial terms (a_4, a_5, etc.) are also taken into account.

The polynomial coefficient a_0 is obtained from the actual radius of the roll. The polynomial coefficients a_2, a_3, a_4, a_5, etc., are defined

so that the desired adjusting range for the CVC system is obtained. The polynomial coefficient a_1 is independent of the adjusting range and of the linear load between the rolls and can thus be freely selected. This wedge factor or linear component a_1 can be selected so that minimal axial forces are produced when CVC rolls are used.

For reasons of practicality, the optimum wedge factor a_1 is determined offline as a mean value of various displacements of the CVC rolls with respect to each other (e.g., minimum, neutral, and maximum displacement). Although it is true that, because a mean value is calculated, the axial forces of the roll bearings are not completely compensated, a minimum value is nevertheless obtained over the entire adjusting range of the rolls.

On the basis of the mathematical considerations and the empirical data, it has been found advantageous for the wedge factor a_1 for a roll described by a third-degree polynomial equation to be in the range of

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$a_1 = -1/20$ to $-5/20 \cdot a_3 \cdot b^2_{cont}$.

Similar reasoning leads to the conclusion that the wedge factor a_1 for a roll described by a fifth-degree polynomial equation can be described by the expression:

$$a_1 = f_1 \cdot a_3 \cdot b^2_{cont} + f_2 \cdot a_5 \cdot b^4_{cont}$$

where

$f_1 = -1/20$ to $-5/20$ and

$f_2 = 0$ to $-7/112$.

Additional features of the invention can be derived from the claims and from the following description as well as from the drawing, in which exemplary embodiments of the invention are illustrated schematically:

FIGS. 1a, 1b, and 1c show a pair of CVC working rolls shifted into various positions with respect to each other along with their backup rolls and also the linear load distribution in the roll gap and between the rolls;

FIG. 2 shows the distribution of the circumferential forces in the contact area between two rolls;

FIG. 3 shows a pair of CVC working rolls with a conventional grind; and

FIG. 4 shows a pair of CVC working rolls with an optimum wedge shape.

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FIGS. 1a, 1b, and 1c show the CVC working rolls 1 shifted into different positions with respect to each other. The working rolls 1 are supported by the backup rolls 2. A rolled strip 3 is located between the working rolls 1.

The load in the roll gap is assumed to be constant across the rolled strip 3 and to be independent of the displacement of the working rolls 1 with respect to each other. It is indicated by the

arrows 4. The load between the CVC working rolls 1 and the backup rolls 2 is distributed unequally over their contact area b_{cont} and changes with the displacement of the working rolls 1. This load is indicated by the arrows 5. The sum of the loads illustrated by the arrows 4 is equal and opposite to the sum of the loads illustrated by the arrows 5.

According to FIG. 2, the load arrows 5 resulting from the shape of the rolls and the local positive or negative relative velocity lead to different circumferential forces Q_i over the contact width b_{cont}. This distribution of the circumferential roll force Q_i causes a torque M around the center 6 of the roll stand, which can lead to the skewing of the rolls 1, 2 and thus to axial forces in their bearings.

This can be prevented by giving the rolls an appropriate grind. In the case of CVC rolls with the roll contour according to a third-degree polynomial equation according to:

$$R(x)= a_0+a_1 \cdot x + a_2 \cdot x^2 + a_3 \cdot x^3$$

only the factor a_1, the so-called wedge factor, is available for varying the grind pattern, because the polynomial coefficient a_0 determines the associated radius of the roll, and the polynomial coefficients a_2, a_3, a_4, a_5, etc., determine the desired adjusting range of the CVC system. Only the wedge factor a_1 is independent of the adjusting range and the linear load between the rolls and can thus be freely selected. In the case of CVC rolls with a contour

defined by a third-degree polynomial, the wedge factor a_1 leads to a minimum torque M when it is in the range of:

$a_1 = -1/20$ to $-5/20 \cdot a_3 \cdot b^2_{cont}$.

For CVC rolls with a contour defined by a 5th-degree polynomial, the torque M reaches a minimum when the wedge factor is:

$a_1 = f_1 \cdot a_3 \cdot b^2_{cont} + f_2 \cdot a_5 \cdot b^4_{cont}$

where

$f_1 = -1/20$ to $-5/20$ and

$f_2 = 0$ to $-7/12$.

FIG. 3 shows a conventionally ground pair of CVC working rolls, which has been laid out with the goal of achieving the smallest possible diameter differences. The tangent 8, which contacts a diameter 7 at one end and the convex part of the roll, and the other tangent 10, which contacts the diameter 9 at the other end and the concave part of the roll, are parallel to the axes of the conventionally ground working rolls. In contrast, the corresponding tangents of the CVC rolls according to FIG. 4, which were laid out with the optimum wedge shape, are parallel to each other but are slanted with respect to the roll axes by the optimum wedge angle [alpha].

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LIST OF REFERENCE NUMBERS

1, 1'	CVC working rolls
2	backup rolls
3	rolled strip
4	arrow (load in the roll gap)
5	arrow (load between the working roll 1 and the backup roll 2)
6	center of the rolling stand
7, 7'	diameter at the end of the roll
8, 8'	tangent
9, 9'	diameter at the other end of the roll
10,10'	other tangent

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Patent Claims

1. Rolling stand with a pair of CVC rolls, preferably a pair of CVC working rolls and a pair of backup rolls, which have a contact area b_{cont} in which a horizontally-acting torque (M) is present, which leads to a skewing of the rolls and thus to axial forces in the roll bearings, characterized in that the torque (M) is minimized by a suitable CVC grind

2. Rolling stand in accordance with claim 1, characterized in that the change in the radius of the CVC rolls is described by the polynomial equation

$$R(x)= a_0+a_1\cdot x + a_2\cdot x^2 + . . . a_n\cdot x^n$$

and preferably the wedge factor a_1 is used as the optimization parameter.

3. Rolling stand in accordance with claim 2, characterized in that the optimal wedge factor a_1 is determined offline as a mean value of various displacements of the CVC rolls with respect to each other (e.g., minimum, neutral, and maximum displacement).

4. Rolling stand in accordance with claim 3, characterized in that the wedge factor a_1 for a roll is described by a third-degree polynomial equation in the range of

$a_1 = -1/20$ to $-5/20 \cdot a_3 \cdot b^2_{cont}$.

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5. Rolling stand in accordance with claim 3, characterized in that the wedge factor a_1 for a roll described by a fifth-degree polynomial equation can be described by the expression:

$$a_1 = f_1 \cdot a_3 \cdot b^2_{cont} + f_2 \cdot a_5 \cdot b^4_{cont}$$

where

$f_1 = -1/20$ to $-5/20$ and

$f_2 = 0$ to $-7/112$.

Figures

FIG.1a

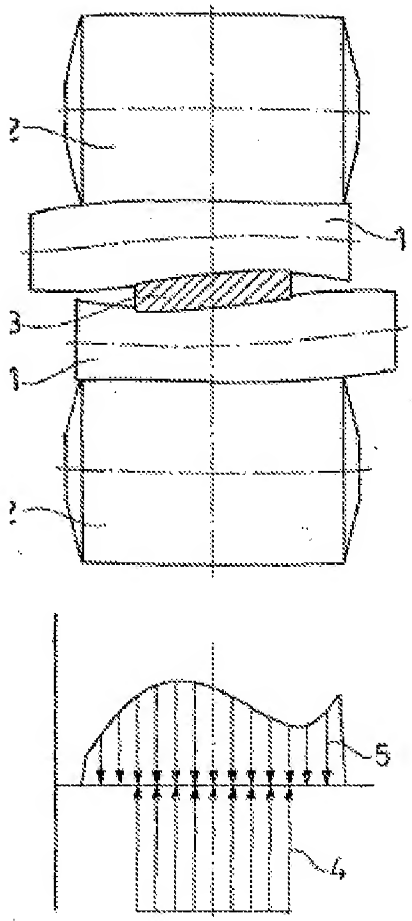


FIG.1b

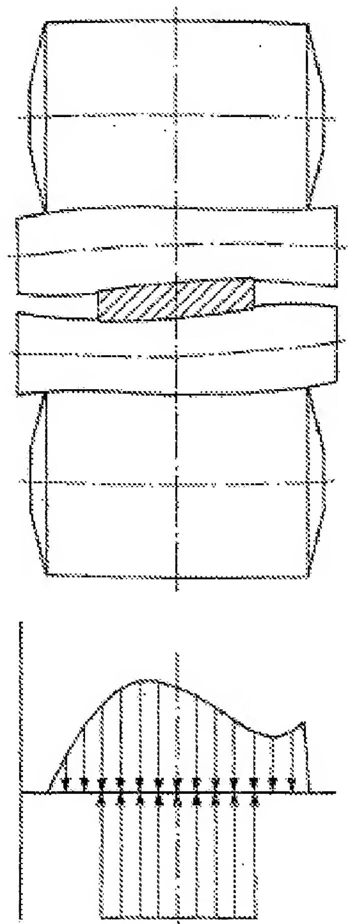


FIG.1c

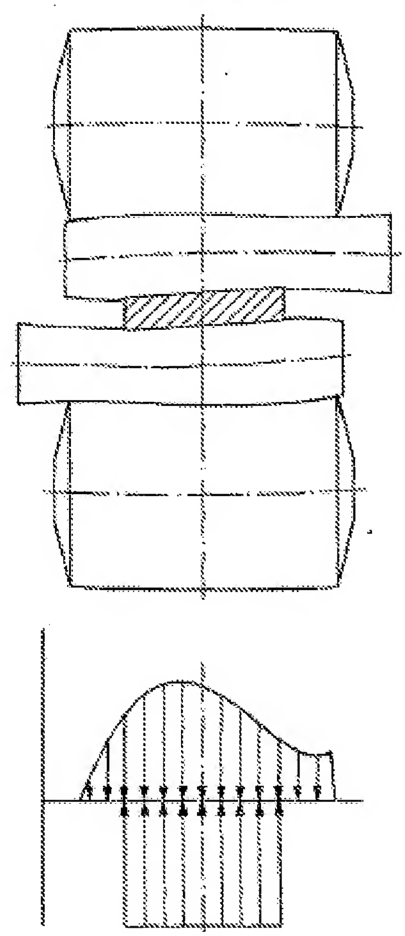


FIG.2

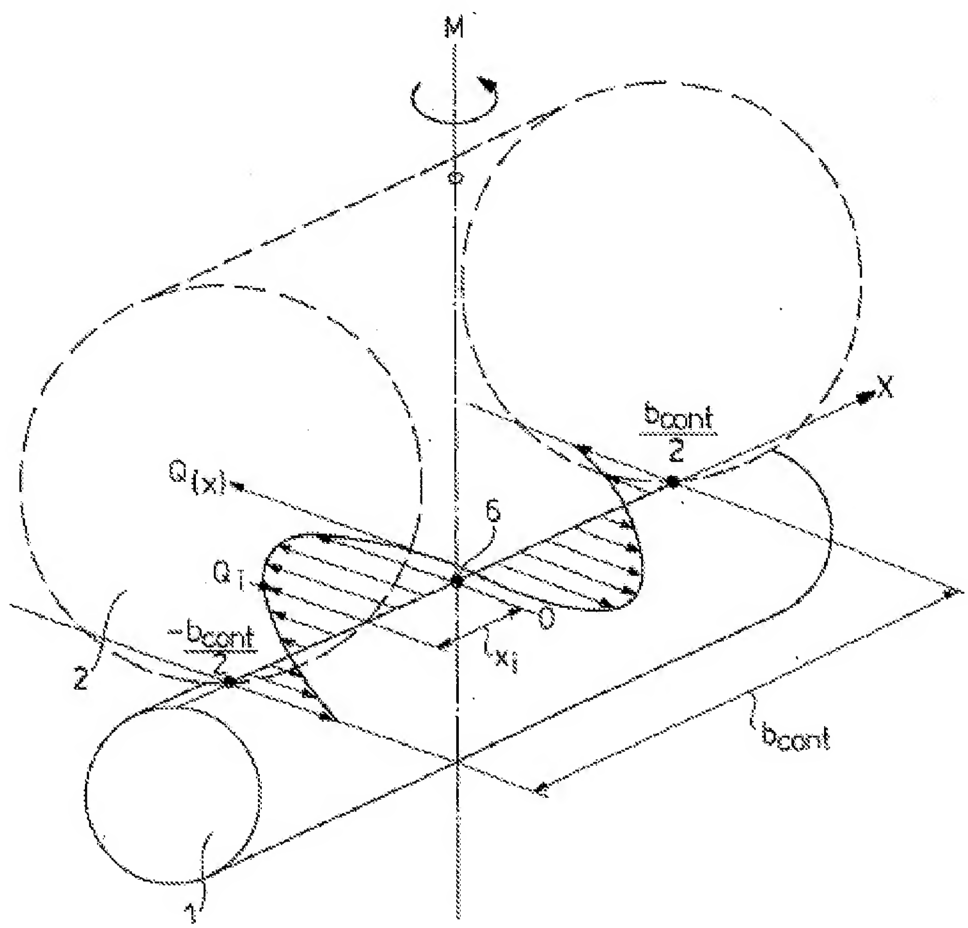
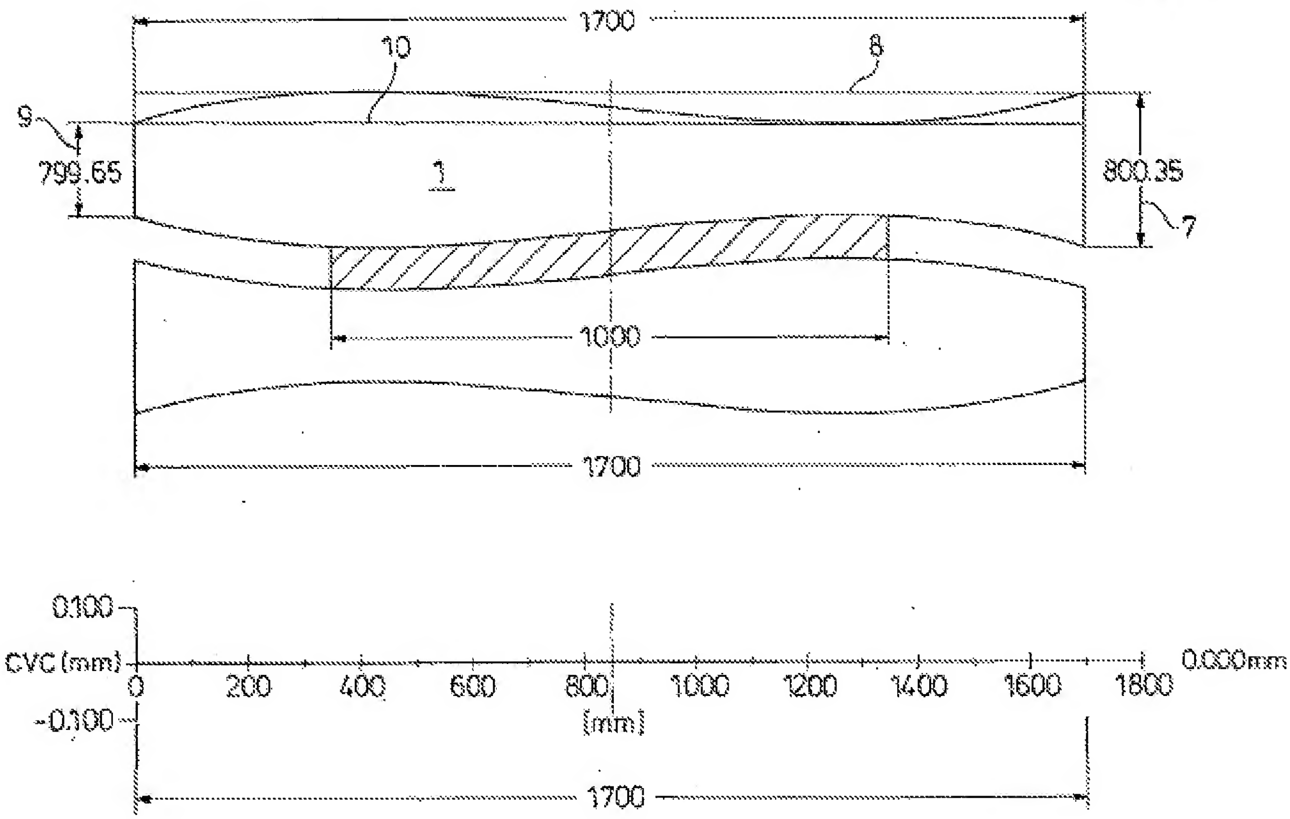


FIG.3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10
8
9
799.65
1
800.35
7
1000
1700
0.100
CVC (mm)
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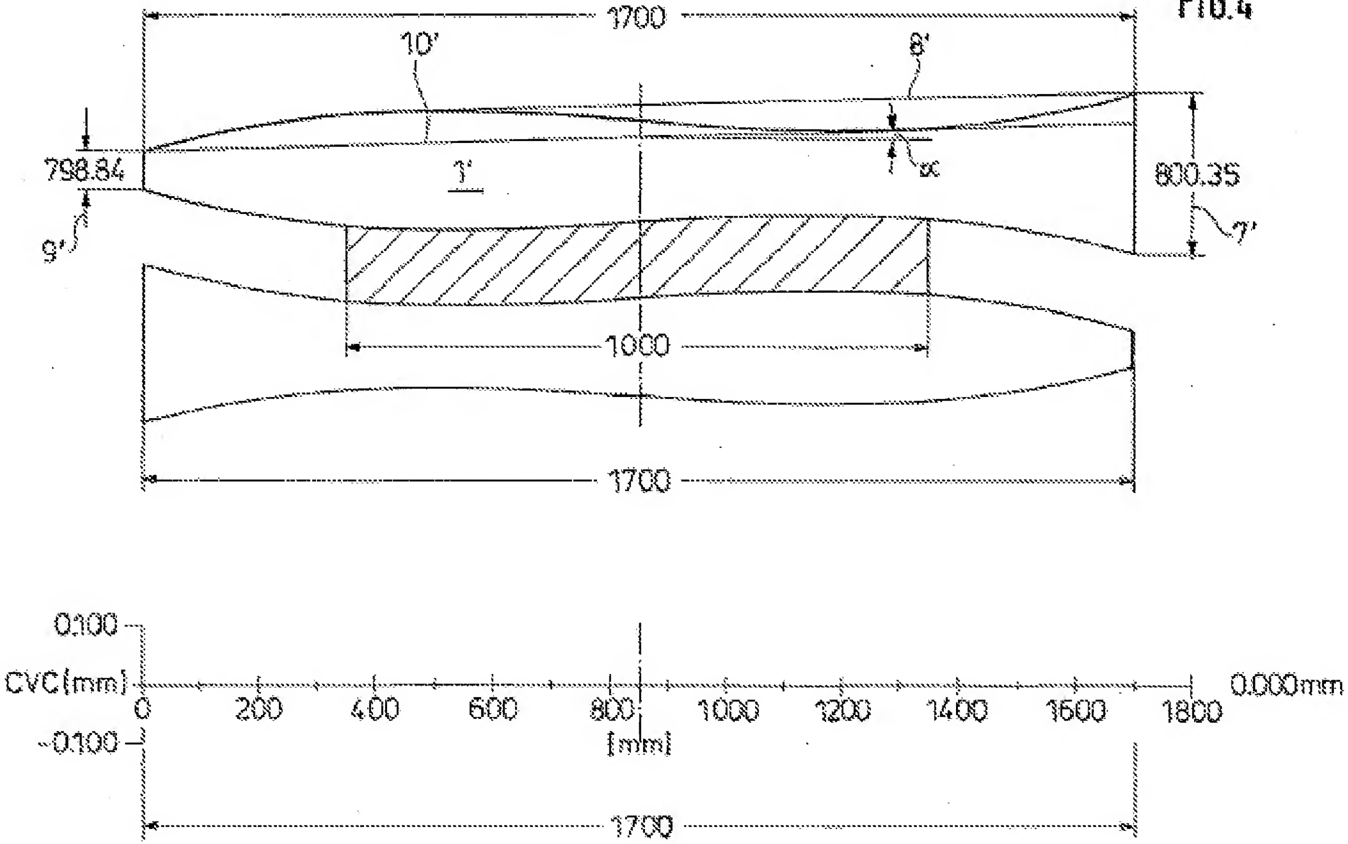
200
400
600
800
1000
1200
1400
1600
1800
0.000mm
-0.100
[mm]
1700

FIG.4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8'
798.84
1'
α
800.35
9'
7'
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0.100
CVC (mm)
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800
1000
1200
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